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AUTHOR Fisher, A. Craig; And Others
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ABSTRACT

The purposes of this study were a) to investigate the relationship between grip strength and the measures of age, height, weight, and the personality traits revealed by the Comrey Personality and Attitude Factor Scales and b) to assess the influence of heredity on height, weight, and grip strength. Fifty-eight pairs of twins (MZ, 30 and DZ, 28) served as subjects. Pearson product moment correlations revealed that weight appeared to be the best predictor of grip strength. When age was partialed out by standard score transformation, weight was no longer the best predictor. It was concluded that age was the best predictor of strength for both males and females. Results also showed that personality was not an important function of the grip strength score. Significant heritability coefficients were found for the factors of height, weight, and grip strength, although not all coefficients reached statistical significance for both sexes. (Four tables of statistical data and two pages of statistical formulas are included along with two pages of references.) (Author/BRB)

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PERSONALITY AND GRIP STRENGTH RELATIONSHIPS BETWEEN MONOZYGOUS AND DIZYGOUS TWINS

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A. Craig Fisher,
Richard E. Stafford,
and
Charles J. Ansorge

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In the past few years there has been a return of interest by psychologists to hereditary components of behavior. One of the strongest reasons for this thrust is the over-emphasis on the social explanation of behavior without an adequate consideration of the biological base. This is very evident in the area of personality theorizing at the present time.

It would seem fairly logical that the physical educator would need to be aware or at least interested in the relative importance of hereditary and environmental components in determining certain motor behaviors. Vandenberg (24) indicated that the domain of motor responses is perhaps the most promising "bet" for human behavior genetic studies. Substantial hereditary components have been shown for some of the traditional motor responses--mirror drawing, beam balance, tapping speed, rotary pursuit hand steadiness, and card sorting. However, no definite relationship has yet been shown between the complexity of the task and heritability (23). In general, it would be fair to say that physical educators are more interested in the area of motor responses, especially those related to sport, than are psychologists.

A Craig Fisher is the chairman of graduate programs in physical education at Ithaca College, Ithaca, New York. Richard E. Stafford is the chairman of psychology at State University College, Oneonta, New York. Charles J. Ansorge is an assistant professor of physical education at the University of Nebraska, Lincoln, Nebraska.

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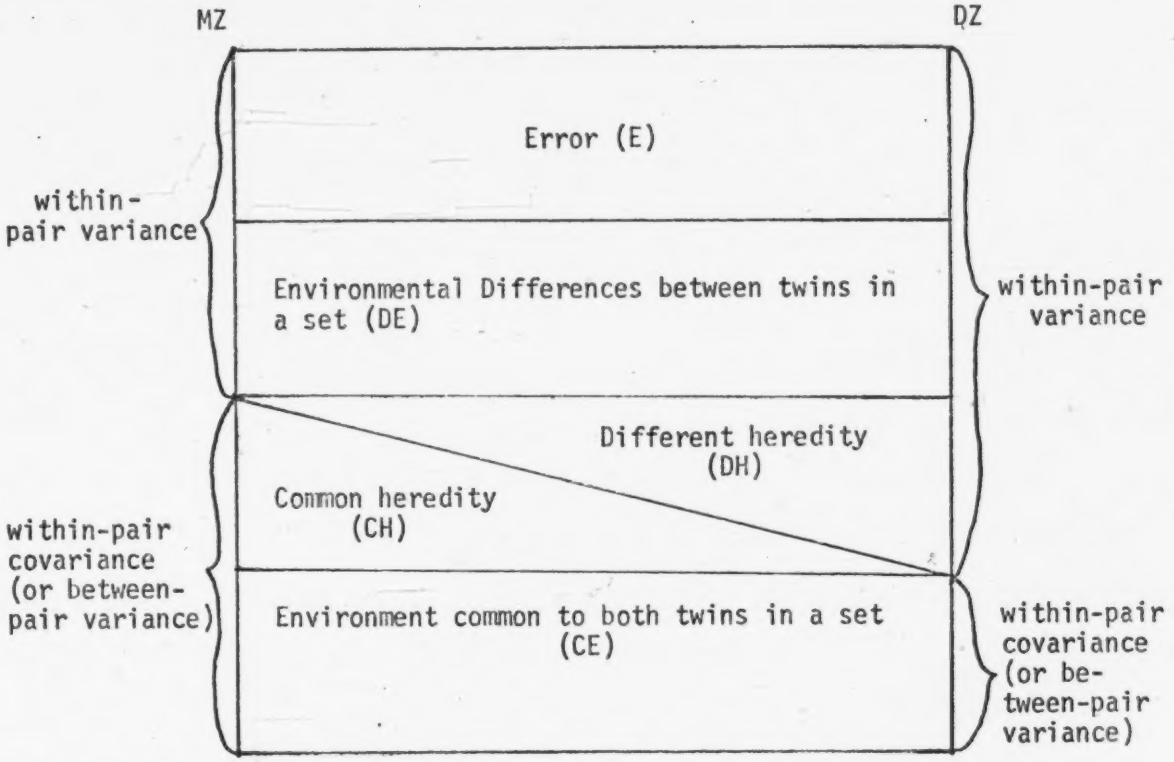
Venerando and Milani-Comparetti (26:80) provide a very concise, albeit harsh, rationale for the significance of genetic studies to skill learning: "If a given trait, required for a certain type of activity, is completely or almost completely conditioned by the genotype, we should seek those who have inherited it from their parents without wasting time and effort in useless training sessions." Not all traits have substantial genetic components and therefore the influence of instruction plays an important part in the acquisition of such behaviors. In the latter case the environmental component is more important than the genetic component.

Of the several methods of determining the relative effects of heredity and environment (28), the twin-method is the most classical for demonstrating the existence of a hereditary component in a given biological phenomenon. Influence of heredity can be inferred from the greater similarity of identical twins than that of fraternal twins. Gedda (6) utilized the twin-method (N = 351 pairs) to investigate the similarity and dissimilarity of sport practices since only six percent of the monozygous (MZ) twins were dissimilar compared to eighty-five percent of the dizygous (DZ) twins. This means that it was highly unlikely for the identical twins to differ as to their sport practices, whereas, such was not the case for the fraternal twins.

Heritability studies cannot answer the question, "How much of trait X is due to heredity and how much is due to the environment?" Gottesman (7) indicated that such a question is meaningless because neither can produce the observed behavior alone. It is a misconception to believe that heredity and environment are dichotomies; it is not an either/or situation. In addition it is just as foolish to believe that inherited characteristics are immutable and that environmental characteristics are easily altered (10).

Jensen (10:6) explained that the "degree of heritability of a behavioral trait simply indicates the extent to which variability is controlled by internal biological rather than social-psychological influences." It delineates the sources of influence, biological or psychological, to which a particular trait is more susceptible. It must be kept in mind, however, that the coefficient of heritability (H) is a population statistic and it cannot be applied to a characteristic of an individual since a single measurement has no variance (28). Simply then, one's score on any trait cannot be partitioned into hereditary and environmental components.

Schematic Representation of Sources of Variances in Twin Data*



From the schematic representation, the concept of heritability can be explained. Indications of hereditary components involved are derived from a comparison of the within-pair variances, the assumption being that the MZ twin

*Adapted from Nichols (1965)

differences represent only environmental and error variance (E + DE) while the DZ twin differences represent environmental and error variance plus hereditary differences (E + DE + DH).

To conclude this brief explanation of the twin-study method and the concept of heritability, it should be noted that there are indeed two answerable questions to be derived from this approach.

1. How much of the variability observed within a group of individuals in a specified environment of a specific measure of a specific trait is attributable to genetic factors?
2. How modifiable by systematic environmental manipulation is the phenotypic expression of each genotype?

Purpose

The purposes of the study were twofold: (1) to investigate the relationship between grip strength and the measures of age, height, weight, and personality traits revealed by the Comrey Personality and Attitude Factor Scales; and (2) to assess the heritability estimates of the measures height, weight and grip strength.

In studies in which strength has been under consideration, hand grip scores have often been utilized since they are reasonably representative of total body strength (5). Positive correlations have been reported between grip strength and age, height, and weight (1,11). The magnitude of the correlation coefficients vary from study to study but they always are positive. The one measure that seems to be the best indicator of grip strength is weight. In fact, Tinkle and Montoye (22:242) have gone so far as to state that "grip strength is directly related to and probably dependent upon body weight . . . in college men."

At first glance, it might seem incongruous to consider the relationship between grip strength and personality traits, but certain investigators have been concerned with the possibility that personality might be overtly expressed on a strength test (12,15,18). Would such traits as achievement need, hostility, and ascendance be related to grip strength performance? The usual result of such studies is that no significant relationship is found between grip and strength and personality traits.

Generally, larger within-pair differences in psychological test performances are found more frequently with DZ twins than with MZ twins (26). In Clark's study (3) with anthropometric characters such as height, weight, and various hand measurements, the within-DZ twin variances exceeded the within-MZ twin variances for every trait. Montoye and Faulkner (14) found such high positive correlations between various hand measurements and grip strength, that it would appear reasonable to speculate that there would also be a significantly greater within-pair variance in grip strength.

Population

Fifty-eight pairs of twins (MZ males = 14, DZ males = 11; MZ females = 16; DZ females = 17) aged 12-18 years served as volunteers in the Louisville Twin Study (supported by grants K3-MH-18,382 and HD 00843), Dr. Stephen G. Vandenberg, principal investigator. All Ss were not present at each testing session.

The zygosity of the Ss was derived from a series of blood group tests which were performed at the Minneapolis War Memorial Blood Bank.

Variables

The measures of age in years, height in inches, and weight in pounds were recorded by E. Grip strength scores, utilizing the Smedley Hand

Dynamometer were measured in kilograms. Each S received three trials with each hand. All scores were recorded and S was asked to reveal his or her dominant hand. This was verified by asking several questions pertaining to his or her hand preference in executing certain activities--throwing a baseball, threading a needle, and dealing cards.

A modification of the Comrey Personality and Attitude Factor Scales (CPS) was administered to the Ss. The CPS reveals 12 personality traits.

Statistical Treatment

The grip scores of the dominant hand were subjected to an ANOVA for repeated observations on the same subjects to investigate any differences between trials. Kroll (13) indicated that if the resultant F ratio was not significant, then the trial means did not fluctuate in any pattern and therefore the arithmetic mean would be the best representative score.

Since age differences were noted, the raw scores of the measures of height, weight, and grip strength were transformed to standard scores within each age group. No attempt was made to partial out sex differences.

An intercorrelation matrix was calculated for the measures of age, height (raw and standard score), weight, (raw and standard score), and grip (raw and standard score). Correlations were reported for males and females separately.

The Comrey personality data were factored into 12 specific traits of personality (Factored homogeneous item dimension - FHID). Scores on the 12 Comrey scales were correlated for age. If any significant correlation coefficients were noted between age and the Comrey scales, age was partialed out of other correlations utilizing that scale.

The National Merit Scholarship Corporation Intraclass Correlation Program (17) was used to compute the intraclass correlation (R) for the MZ and DZ twins on the measures of height, weight, and grip strength. The program also computed the heritability ratios from the intraclass correlations. Intraclass correlation expresses the relationship between two groups of individuals in regards to a single variable in contrast to the Pearson r, which is an interclass correlation coefficient used to express the relationship between two variables for a single group of individuals. R gives an estimate of the degree of similarity between pairs of twins. The significant differences test is a t ratio.

MZ within-pair variance and DZ within-pair variance on the means of height, weight, and grip strength were compared by means of a single-factor ANOVA. To test the statistical significance of the expected increased within-pair variance in fraternal twins compared to identical twins, the ratio of the two within-pair variances is evaluated by the F test following Clark (3).

Results and Discussion

The intercorrelation matrix of the measures of age, height, (raw and standard score), and grip (raw and standard score), is reported in Table 1. The reason for transforming the raw measures to standard scores can readily be seen by noting the differences in the correlation coefficients with and without age partialed out. Other investigators have cautioned about the acceptance of zero-order correlations (19,22). The results reinforce the fact that of the measures of age, height, and weight, weight is the best predictor of grip strength for both males and females. This finding is in accordance with Everett and Sills (5), Pierson and O'Connell (19) and Tinkle and Montoye (22).

Table 1

Correlations Between Grip Strength, Height, Weight with and without Age partialed out

	Height		Height (Standard Score)		Weight		Weight (Standard Score)		Grip		Grip (Standard Score)	
	M	F	M	F	M	F	M	F	M	F	M	F
Age	+.61**	+.16	+.11	-.60**	+.65**	+.26	+.27	-.64**	+.77**	+.48**	+.29	-.72**
Height	.00	.00	+.84**	+.67**	+.85**	+.60**	+.75**	+.29	+.66**	+.41**	+.45**	+.21
Height (Standard Score)	+.84**	+.67**	.00	.00	+.60**	+.23	+.69**	-.73**	+.30	-.07	+.33*	+.65**
Weight	+.85**	+.60**	+.60**	+.23	.00	.00	+.84**	+.41**	+.84**	+.57**	+.68**	+.13
Weight (Standard Score)	+.75**	+.29**	+.69**	+.73**	+.84**	+.41**	.00	.00	+.62**	-.01	+.67**	+.64**
Grip	+.66**	+.41**	+.30	-.07	+.84**	+.57**	+.62**	-.01	.00	.00	+.82**	+.17
Grip (Standard Score)	+.45**	+.21	+.33*	+.65**	+.68**	+.13	+.67**	+.64**	+.82**	+.17	.00	.00

*p $\leq$ .05
**p $\leq$ .01

The apparent lower correlation coefficients for females between grip and the measures of age, height, and weight may be due to the lesser variability among the grip scores for the females than for the males. These results appear to be reflecting sex differences in strength development. Increments in grip strength have been shown to be similar for both sexes until after age 13. After this age, increments in the grip strength of males increase more rapidly until at one point the increment is nearly double for males (11).

Since significant correlations were revealed between age and some of the Comrey personality scales (Table 2), partial-order correlations were necessary. The major purpose was to reveal the correlation between the personality traits and grip strength. Age was partialed out of both neuroticism and hostility for males, but the resulting correlations between these traits and grip were still significant, -.48 and -.32 respectively. The interpretation of these correlations means that the higher the scores on neuroticism and hostility the lower the grip score. There is a strong indication that neuroticism and hostility are not discrete items since Vandenberg, Comrey and Stafford (25) reported an intercorrelation of +.50.

It is readily seen that the correlations between grip and neuroticism and hostility are contaminated because of the significant correlations previously recorded between the measures of height and grip (+.33, age partialed out) and weight and grip (+.67, age partialed out).

The low correlations between grip strength and the Comrey personality scales are very similar to other previous attempts to correlate grip strength and personality traits. Dunn (4), Moore and Sturm (15), and Pargman (18), all reported only isolated significant correlation coefficients between grip strength and personality. Moore and Sturm (15:111) concluded their research

Table 2

Scores on the 12 Comrey Personality and Attitude Factor Scales for Males and Females correlated with Grip Scores, Height and Weight Corrected for Age

	Age		Standard Score Height		Standard Score Weight		Standard Score Grip	
	M	F	M	F	M	F	M	F
1. Empathy	-.09	+.14	-.07	-.21	+.19	-.10	+.21	-.22
2. Neuroticism	-.40**	+.04	-.10	+.13	-.44**	+.12	-.53**	+.10
3. Welfare State Attitudes	+.14	+.22	+.11	-.17	+.21	-.21	+.11	-.27*
4. Achievement Need	-.09	-.20	-.17	+.17	+.05	+.10	-.06	+.10
5. Dependence	-.40**	-.09	-.07	-.03	+.09	-.28*	-.01	-.01
6. Compulsion	-.15	.00	-.16	+.14	+.04	-.01	-.03	-.13
7. Self-control	+.10	-.04	-.22	-.16	-.08	-.10	+.02	-.10
8. Religious Attitudes	-.10	+.15	+.23	-.10	+.24	-.03	+.20	-.19
9. Hostility	-.28	-.23	-.42**	+.19	-.47**	+.36**	-.38**	+.17
10. Punitive Attitudes	+.12	.00	+.04	+.18	-.13	+.09	+.15	+.02
11. Shyness	+.01	+.29*	.00	-.07	-.16	-.05	.00	-.10
12. Ascendance	+.05	+.06	-.04	-.12	-.07	+.07	-.11	-.06

*$p \leq .05$
**$p \leq .01$

report by stating: "If hand-grip is related to that elusive personality trait called 'drive,' the results of this study demonstrate its elusiveness."

Tables 3 and 4 reveal three heritability measures for height, weight and grip--t, F, and H. If the intraclass correlation within-MZ twins is significantly greater than within-DZ twins, and the within-MZ twin variance is significantly less than the within-DZ twin variance, then this is evidence of the relative importance of heredity in producing that trait. It is entirely possible for the same trait to be more or less influenced by heredity in different samples and in the case of the present study, for different sexes.

Weight in males was shown to have a significant hereditary component by all the assessments of heritability. The same trait for females undergoes a relatively greater environmental determination. This reflects one of our cultural dictates where certain ideals have been created, i.e. the acceptable weight for females between 111 and 125 pounds.

Females reveal relatively greater hereditary components in height and weight. This might be interpreted again in light of cultural dictates. It would appear that females have traditionally experienced less strenuous physical activity than males and this certainly could explain the differences in the hereditary components for strength and might even explain the height differences. Optimal stress enhances the rate of growth.

The discrepancies between the significance of t and F is due to the variances of the twin' scores. The t ratio takes into account both between-and within-variance whereas the F ratio is only concerned with within-variance. Therefore, unless the total variance of the DZ twins equals the total variance of the MZ twins, these two methods of assessing heritability may give different results.

Table 3

Intraclass R's For Identical (MZ) and Fraternal (DZ) Twins and t-ratios Of Differences Between R's On Height, Weight, Grip Strength

	Males					Females				
	N (prs)	MZ	N (prs)	DZ	t	N (prs)	MZ	N (prs)	DZ	t
Height	9	.92	8	.77	.94	12	.96	10	-.22	4.31**
Height (Standard Score)	9	.85	8	.65	.79	12	.95	10	.56	2.38**
Weight	10	.99	7	.76	2.63**	16	.89	11	.86	.29
Weight (Standard Score)	10	.72	7	.76	.14	16	.96	11	.95	.27
Grip Strength	14	.93	11	.89	.52	16	.86	17	.64	1.38
Grip Strength (Standard Score)	14	.83	11	.72	.60	16	.91	17	.69	1.77*

*$p \leq .05$
**$p \leq .01$

Table 4

F-ratios of Within Pair Variance and Holzinger's Heritability Coefficients (H) For Height, Weight, Grip Strength

	Males		Females	
	F	H	F	H
Height	2.73	.63*	10.44**	.96**
Height (Standard Score)	2.40	.57*	11.79**	.88**
Weight	14.41**	.95**	3.96**	.19
Weight (Standard Score)	.80	-.16	4.35**	.21
Grip	.97	.37	2.92*	.61*
Grip (Standard Score)	1.07	.41	3.70**	.73**

*p $\leq$ .05
**p $\leq$ .01

Conclusions

Age, height, and weight are all positively related to grip strength. The magnitude of the correlations decreases when a partial-out technique is utilized. Of the measures of age, height, and weight, weight is the best indicator of grip strength.

Personality appears not to be highly related to a strength task. Although it is often speculated that an individual expresses his or her personality through movement, performance on a strength task appears to be personality-free.

Genetic components appear to play a relatively greater role in determining the variability of weight in males, and height and grip strength in females. On the other hand, environmental components appear to have a relatively greater influence on the variability of height and grip strength in males, and weight in females.

The twin-study method could prove useful in countless areas of physical education research. There are many untested beliefs concerning the relative permanence and malleability of certain physical abilities; undoubtedly light could be shone on these areas.

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Statistics and Formulae

Transformed Standard Scores (20)

$$S_i = \frac{S_s}{S_x} X_i + \bar{X}_s - \frac{S_s}{\hat{S}_x} \bar{X}_x$$

S_i is the transformed standard score

X_i is the raw score

S_s is the arbitrary standard deviation (suggest 15)

$\hat{S}_x$ is is the approximate standard deviation (read from the smoothed curv for each specific age)

$\bar{X}_s$ is the arbitrary mean (suggest 50)

$\bar{X}_x$ is the approximate mean (read from the smoother curve for each specific age)

Within-pair Variance

$$\sigma_w^2 = \Sigma \left(\frac{X_1 - X_2}{N}\right)$$

X_1 is the value for twin 1

X_2 is the value for twin 2

N expressed as pairs

F-ratio (3)

$$F = \frac{\sigma^2 DZ}{\sigma^2 MZ}$$

Intraclass Correlation (17)

$$R = \frac{4N\Sigma XY - (\Sigma X+\Sigma Y)^2}{2N(\Sigma X^2+ \Sigma Y^2) - (\Sigma X-\Sigma Y)^2}$$

ΣXY is the within-pair cross-product summed over pairs
ΣX is the sum of all twin 1 values
ΣY is the sum of all twin 2 values
ΣX^2 is the sum of squares over all twin 1 values
ΣY^2 is the sum of squares over all twin 2 values

Test of Significant Differences of R's

$$t = \frac{z_{MZ} - z_{DZ}}{\sqrt{\frac{1}{N_{MZ}-3} + \frac{1}{N_{DZ}-3}}}$$

z = is Fisher's z coefficient
N = expressed as pairs
df = $N_{MZ} + N_{DZ} - 3$

Heritability Coefficient (9)

$$H \text{ est.} = \frac{\sigma^2 DZ - \sigma^2 MZ}{\sigma^2 DZ} = \frac{R_{MZ} \quad R_{DZ}}{1 - R_{DZ}} = \frac{DH}{DH+DE+E}$$

Test of Significance of H (9)

$$F = \frac{1}{1 - H}$$

Pearson Product-Moment Correlation

$$r = \frac{N\Sigma XY - \Sigma X \cdot \Sigma Y}{\sqrt{\left[N\Sigma X^2 - (\Sigma X)^2\right] \cdot \left[N\Sigma Y^2 - (\Sigma Y)^2\right]}}$$